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Le guide est destiné à l'enseignant des nouveaux programmes de chimie et de physique de quatrième et cinquième année du secondaire. Le document est disposé de la façon suivante: le contenu original des cours (sauf Science 412) est présenté sur le côté gauche de la page ; le contenu proposé par le Ministère, qui doit être enseigné en 100 heures au lieu des 150 heures de l'ancien programme, est présenté sur le côté droit de la page. Ces suggestions devraient assurer un certain degré d'uniformité à l'enseignement. Néanmoins, selon les besoins des étudiants et le temps d'enseignement alloué, les professeurs restent libres d'organiser ces cours de manière différente.

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INFORMATION DOCUMENT

REORGANIZATION OF THE CHEMISTRY AND PHYSICS PROGRAMS

**SECOND CYCLE
SECONDARY SCHOOL**

January 1987

Québec ☐☐

**REORGANIZATION OF THE CHEMISTRY
AND PHYSICS PROGRAMS**

**SECOND CYCLE
SECONDARY SCHOOL**

Direction générale des programmes
Direction de la formation générale

Le présent document remplace
celui paru dernièrement sous
le code: 16-3155A. Ce dernier
a été périmé.

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INTRODUCTION

This document is intended as a guide to facilitate teaching of the current chemistry and physics programs that are being offered in fourth and fifth year of secondary school.

Over the past several years, the teaching time and content of these programs have undergone certain modifications. It became evident that it was necessary to revise them further to reflect the present educational realities. This process is underway; in the meantime, this document provides suggestions for the reorganization of the old programs to meet the requirements of the new Regulation Respecting the Basis of Secondary School Organization.*

As the new Regulation for Secondary IV and V is being implemented gradually and the new science programs are not yet available, the existing ones will continue to be taught in the meantime. In order to use these two programs under the new Regulation, certain accommodations will have to be made. For instance, when these two programs were developed, the suggested teaching time was one hundred and fifty (150) hours, the equivalent of two (2) units; under the new Regulation students are required to take four (4) credits in science (chemistry or physics) and the suggested teaching time is one hundred (100) hours.

This document is organized in the following manner: the original content of the courses in question (except Science 412) is presented on the left side of the page; the content proposed by the Ministère in order to make it possible to teach the courses within the suggested teaching time of 100 hours is presented on the right side of the page. These suggestions should ensure a certain degree of uniformity throughout the province. However, depending on the needs of students concerned and the teaching time that is allotted at the local level, teachers could organize these courses differently.

* Québec, ministère de l'Éducation, Direction générale du développement pédagogique, Regulation Respecting the Basis of Secondary School Organization, 1983. Hereafter referred to as the Regulation.

This guide focuses on the chemistry and physics programs that are currently being evaluated at a local level rather than by the Ministère. Areas in which teachers have a certain amount of flexibility have already been specified for the programs leading to secondary school leaving examinations. These areas were identified in December 1984 in a document entitled "Modifications au bulletin d'information pour l'examen 1985 (Chimie, Physique)" and are presented in more detail in the "Information Document on the 1986 Examination (Chemistry and Physics)." A letter attached to this last document outlines the guidelines applicable to areas in which teachers have a certain amount of flexibility, as well as the criteria for their selection; it also includes additional information on these two programs.

CRITERIA FOR THE SELECTION OF AND GUIDELINES FOR WORKING WITHIN THE AREAS OF FLEXIBILITY

"Areas of flexibility" are portions of the program which teachers may condense. Criteria for selecting these areas are, for the most part, the same for all the programs. Some of the criteria may vary, however, depending on the discipline (chemistry or physics) or status of the course (whether or not it is considered to be a prerequisite to a higher-level course). For example, complete sections of the physics courses can easily be made optional since these stand on their own and are not necessarily dependent on other sections. Such is not always the case for chemistry; knowledge of certain related content in one section of a chemistry course is often needed to learn concepts in another section.

In the case of a course identified as a prerequisite to another course, certain sections of one could be condensed and then integrated into the other. This does not apply to courses that are offered for only one year.

Criteria for the Selection of the Areas of Flexibility

The criteria used for determining the areas of flexibility in this document are listed below.

GENERAL CRITERIA:

- . Length: They should keep as much as possible within the allotted teaching time.
- . Level of Difficulty: They should retain a certain level of difficulty, especially with respect to Chemistry 462, 562 and Physics 452, 552. The teaching time is reduced but the students' intellectual abilities remain the same.

- . Repetition: They should retain topics that are covered at both the Secondary IV and V levels; at the Secondary V level the flexibility rests in the degree to which the topic is developed. This criterion applies particularly to students who choose to take chemistry or physics at both level IV and level V, i.e., certain topics covered in Secondary IV should not automatically be eliminated at the Secondary V level, but should be considered as areas to be explored in greater detail.
- . Laboratory Experiments: They should use suitable subjects in experiments, since the experimental approach is so crucial to the scientific training of young people.
- . Logic: They should adhere as closely as possible to the logical sequence of a course and foster a rational use of existing instructional materials.

SPECIFIC CRITERIA:

- . Prerequisite sites: They should take into account the prerequisites needed for further studies, i.e., at the CEGEP level.
- . Information Document: They should abide by the decisions set forth previously in the information documents concerning examinations for science programs leading to secondary school leaving examinations.
- . Orientation of Future Programs: They should implement, as much as possible, changes that are relevant to the orientation of future programs. For example, they should integrate mathematical knowledge necessary for further learning and for becoming familiar with the scientific method as a process.

Guidelines for Working Within the Areas of Flexibility

It is by varying the scope of certain areas of the course (those which are considered to be areas of flexibility) that the teacher will enable students to complete the course within the new teaching time allotted to it. In working within these areas, teachers should keep in mind the following principal guidelines. They should:

1. Help students to learn the essential content within the areas of flexibility of the course.
2. Incorporate the concepts contained in these areas into other parts of the course, for instance, as introductory material or as examples.
3. Present these concepts as projects: for example, research, discussions, field trips, to be carried out by the students.
4. Present, in the form of demonstrations, certain laboratory experiments that are normally done by the students and that are associated with the areas of flexibility.
5. Evaluate learning achievements in topics covered in the course. For courses leading to secondary school leaving examinations, subjects covered in the areas of flexibility will not be tested, in order to ensure fairness and uniformity. However, it is up to the teachers to evaluate the learning accomplished within these areas in light of the objectives pursued in their teaching.
6. Keep in mind the principle that it is up to the individual teacher to adapt his/her teaching to suit his/her own personality, the students concerned, the time and materials available, etc. The suggestions contained in this document are intended only as guidelines to help teachers develop their own instructional approaches.

CLARIFICATIONS CONCERNING PROGRAMS LEADING TO SECONDARY SCHOOL LEAVING EXAMINATIONS

Although basic information is contained in the "Information Document on the 1986 Examination (Chemistry and Physics)," it seemed useful to provide further clarification.

Consider the example of Chemistry 462. Teachers are well aware that Chapter 1 of the official program, which covers "basic concepts," is really a chapter on basic mathematical skills and concepts that are prerequisite to learning material that is covered later in the program. The basic skills and concepts can therefore be integrated with this material, and studied and evaluated at an appropriate time.

The same applies to Chapter 2, which covers the "scientific method." This method constitutes a process which the student learns gradually as he/she acquires more knowledge. Evaluation, therefore, should not be a measure of the student's knowledge of the steps involved in the scientific method, but of the student's progress in developing this way of thinking.

It is therefore natural that the secondary school leaving examination contain no questions that are specifically related to chapters such as Chapters 1 and 2. It is nevertheless up to the teacher to evaluate, as a part of his/her teaching, those sections of the course that are not evaluated by the Ministère. In fact, the curriculum guide for this program (Document 16-3139A, Booklet A) suggests, on page 6, a way of integrating these two chapters with other related content.

It should be noted that in these information documents the word "optional" refers to the time allotted to these sections, to the teaching material and to the depth to which these subjects are studied. For example, some of the concepts included in the chapters mentioned earlier cannot be omitted. However, they can be given less time, less thorough treatment, they can be integrated with other concepts, their teaching strategy can be modified, etc. For this reason, and given the variety of ways for working within these areas of flexibility, the Ministère has decided not to evaluate them, out of a concern for fairness to the student.

CONTENT AND OBJECTIVES OF THE CHEMISTRY 442 PROGRAM

The objectives of the Chemistry 270-442 program, taken from the curriculum guide (Document 16-3139A - Booklet A), are listed in this document on the left side of the page. The suggested teaching time was originally 120 to 150 hours. The objectives specific to Chemistry 270-462 have been omitted. This is why certain of the objectives are missing in the numerical order, which has been kept the same as in the original version of the curriculum guide.

A model designed to make it possible to teach the courses in 100 hours appears on the right side of the page. For some of the sections, notably Sections 1.00 and 2.00, suggestions for grouping together certain concepts are included. For other sections, it should be noted that certain objectives are not repeated on the right side since it is not necessary to cover them for their own sake, but only to the extent that they are useful for acquiring other knowledge, or for purposes of enrichment.

If the modified versions of the Chemistry 462 and Chemistry 442 programs are compared, it can be noted that certain sections have become areas of flexibility in Chemistry 462, while they have retained their essential status in Chemistry 442, which is not a prerequisite to another course. For example, this is the case for the chapter on acids and bases. It is believed that the degree of difficulty of these concepts is very appropriate to the 442 level. The interest that this topic could arouse in students and the possibility of relating it to daily life make it an important topic to integrate into any chemistry program. However, this topic has been designated as an area of flexibility for Chemistry 462 because it is part of Chemistry 562 (the usual follow-up to Chemistry 462) and because certain of the concepts can be integrated into the chapter on solutions in Chemistry 462.

Regardless of whether a course is considered to be a prerequisite to another course or not, all the criteria mentioned in the previous pages have been taken into account in establishing the areas of flexibility. It is nevertheless up to the teachers to make other adjustments, if need be, using the guidelines outlined at the beginning of this document.

TOTAL TEACHING TIME 150 hours

1.00 BASIC CONCEPTS

1.10 Basic Concepts

1.11 Mass

1. To define "mass."
2. To name the basic unit of mass.

1.12 Volume

3. To define "volume."
4. To name the unit of volume.

1.13 Density

5. To define "density."
6. To express density as a ratio.
7. To state the formula for density.
8. To state a unit of density.
9. To identify, from among a certain number of units, those which express:
 - a) mass,
 - b) volume,
 - c) density.
10. To calculate, from experimental data, the density of:
 - a) a solid,
 - b) a liquid,
 - c) a gas.

TOTAL TEACHING TIME 100 hours

1.00 BASIC CONCEPTS

1.10 Basic Concepts

As mentioned in the curriculum guide, these concepts will be taught only if the need arises. Many of these basic concepts can be grouped together and taught by means of a laboratory experiment or demonstration. For example: determining density (1.13) could be the subject of a laboratory experiment.

TOTAL TEACHING TIME 150 hours

1.20 Basic Techniques

1.21 Measuring: a) length
b) area

11. To measure:
- a) the length,
 - b) the area, and
 - c) the volume of an object.

12. To measure the volume of:
- a) a solid,
 - b) a liquid,
 - c) a gas.

13. To measure the mass of:
- a) a solid,
 - b) a liquid,
 - c) a gas.

1.22 Reading Instruments

14. To read measurement instruments usually found in a laboratory.

1.23 To formulate an operational definition for and to carry out the techniques of:

- 15. 16. sedimentation, settling;
- 17. 18. decantation, decanting;
- 19. 20. filtration, filtering;
- 21. 22. centrifugation, centrifuging;
- 23. 24. precipitation, precipitating;
- 25. 26. dilution, diluting;
- 27. 28. distillation, distilling;
- 29. 30. crystallization, crystallizing;
- 31. 32. dissolution, dissolving.

TOTAL TEACHING TIME 100 hours

1.20 Basic Techniques

As mentioned in the curriculum guide, these concepts will be taught only if the need arises. Many of these basic concepts can also be grouped together and taught by means of a laboratory experiment or demonstration. For example: the various separation techniques (1.23) can be demonstrated. Section 3.22 of Unit 3 can be included in this section, or, Section 1.23 of Unit 1 can be grouped with this portion of Unit 3.

TOTAL TEACHING TIME 150 hours

1.30 Basic Mathematics

1.31 Algebraic Operations

- 33. To isolate a variable of an algebraic expression.
- 34. To calculate the value of a variable, given the value of the other variables.

1.32 Scientific Notation

(Ref.: Doc. 16-3138A 1976 edition)

- 35. To convert a number expressed as a decimal into an exponential expression and vice versa. ($0.001 = 10^{-3}$)
- 36. To add, subtract, multiply and divide decimal numbers.

1.33 Exponents

- 37. To multiply and divide exponential expressions.

1.34 Ratios and Proportions

- 39. To solve ratios and proportions problems expressed as whole numbers in the form of simple fractions.

1.35 Calculation of Percentage

- 40. To calculate a percentage.
- 41. To calculate the mass of the different components of a substance, given its percentage composition.

1.36 Preparation of Graphs

- 42. To correctly prepare a graph from a table of data.

1.37 Interpretation of Graphs

- 43. To interpret a graph.

TOTAL TEACHING TIME 100 hours

1.30 Basic Mathematics

The necessary mathematical operations can be taught whenever they become indispensable to the learning of additional knowledge.

TOTAL TEACHING TIME 150 hours

2.00 THE SCIENTIFIC METHOD *

2.10 Description of the Scientific Method

1. To define "observation."
2. To define "interpretation."
3. To observe and describe a given object.
4. To identify, in a description, the qualitative observations, the quantitative observations and the interpretations.
5. To identify, in an organized collection of data (e.g. a table), a common factor or a generalization.
6. To express data based on two variables:
 - a) qualitatively, as a statement describing the relationship;
 - b) quantitatively, as a table summarizing the information given;
 - c) graphically;
 - d) mathematically, as a formula.

TOTAL TEACHING TIME 100 hours

2.00 THE SCIENTIFIC METHOD *

2.10 Description of the scientific method

The scientific method should be taught as a process to be developed gradually, along with the acquisition of other knowledge. Emphasize those steps which are more readily understood by students.

* The program suggests a less rigid approach to the steps in the scientific method than that ordinarily found in the textbooks recommended to students. It is up to the teacher to be flexible and use the most appropriate approach in any given situation presented to the students. These objectives constitute the minimum requirement.

TOTAL TEACHING TIME 150 hours

2.20 Uncertainty

2.21 Sources of Error:

- a) human beings,
- b) instruments.

- 9. To correctly identify the absolute error in reading a metre stick, a scale, a graduated cylinder, a thermometer, etc.

2.22 Expressing Error:

- a) In readings

- 10. To express absolute error using the proper number of significant digits, or using the symbol (+ or -) (Ref. Doc. 16-3138A 1976 edition).

- b) In computations

- 11. To identify the rules for expressing errors resulting from the addition and subtraction of measurements in a significant manner.
- 13. To express, using the symbol ($\pm$), errors in measurements obtained through additions and subtractions.

TOTAL TEACHING TIME 100 hours

TOTAL TEACHING TIME 150 hours

3.00 MATTER *

3.10 States,** Properties and Changes

3.11 States

1. To identify the three states of matter by naming their respective properties.

3.12 Physical and Chemical Properties

2. To identify, from a list of properties of matter, those which are:
 - a) physical,
 - b) chemical.

3.13 Physical and Chemical Changes

3. To identify from a list of changes, those which are:
 - a) physical,
 - b) chemical.

TOTAL TEACHING TIME 100 hours

3.00 MATTER *

3.10 States,** Properties and Changes

3.11 States

1. To identify the three states of matter by naming their respective properties.

Note: With the help of suitable models, indicate the three states of matter. (See 4.10)

3.12 Physical and Chemical Properties

2. To identify, from a list of properties of matter, those which are:
 - a) physical,
 - b) chemical.

3.13 Physical and Chemical Changes

3. To identify from a list of changes, those which are:
 - a) physical,
 - b) chemical.

* This operational unit is addressed to students in courses 442 and 462. Instead of teaching the content in a systematic way, teachers might find it beneficial to introduce the topics as they teach other sections of the program and evaluate whether or not the students have achieved the objectives.

**Some authors use the terms "states" and "phases" in different ways; in this document the word "phase" will refer to the homogenous parts of a system.

TOTAL TEACHING TIME 150 hours

4. To describe the following physical changes:
fusion, solidification, vaporization, condensation and sublimation.
5. To name 2 differences between a physical and a chemical change.

3.20 Macroscopic Classification of Matter

3.21 Definitions

6. To define "system."
7. To define "phase."
8. To define "homogeneous substance" in terms of phase.
9. To define "heterogeneous substance" in terms of phase.

3.22 Mixtures

10. To separate the components of a mixture using an appropriate technique.
11. To list 3 characteristics of a mixture.

TOTAL TEACHING TIME 100 hours

4. To describe the following physical changes:
fusion, solidification, vaporization, condensation and sublimation.

Note: To this section could be added Objectives 37 and 38 of Unit 6. In order to enhance student interest, teachers could use everyday examples to illustrate these changes.

3.20 Macroscopic Classification of Matter

Note: The classification of matter may be illustrated by means of a table.

3.21 Definitions

8. To give an operational definition of "homogeneous substance."
9. To give an operational definition of "heterogeneous substance."

3.22 Mixtures

10. To separate the components of a mixture using an appropriate technique.

TOTAL TEACHING TIME 150 hours

3.23 Solutions

12. To define "solution" in terms of phase.
13. To state 3 properties of solutions.
14. To distinguish between a solution and a mixture in terms of phase.

3.24 Pure substances: a) compounds
b) elements

15. To experimentally determine the melting or boiling temperature of a pure substance.
16. To define a pure substance.
17. To identify 3 characteristics of a pure substance.
18. To distinguish between a pure substance and a solution.
19. To distinguish between a pure substance and a mixture.
20. To define "chemical compound."
21. To identify 2 characteristics of compounds.
22. To give an operational definition of "element."
23. To make an operational distinction between an element and a compound.
24. To distinguish a compound from a mixture.
25. To state the "law of definite proportions."
26. To explain the "law of definite proportions."

TOTAL TEACHING TIME 100 hours

3.23 Solutions

12. To give an operational definition of "solution."

3.24 Pure substances: a) compounds
b) elements

15. To experimentally determine the melting or boiling temperature of a pure substance.
16. To define a pure substance.
17. To identify 3 characteristics of a pure substance.
19. To distinguish between a pure substance and a mixture.
20. To define "chemical compound."
21. To identify 2 characteristics of compounds.
22. To give an operational definition of "element."
23. To make an operational distinction between an element and a compound.
24. To distinguish a compound from a mixture.

TOTAL TEACHING TIME 150 hours

3.30 Energy

3.31 Forms

- 27. To list several forms of energy.
- 28. To define "potential energy."
- 29. To define "kinetic energy."

3.32 Conservation

- 30. To give some examples of energy conservation.
- 31. To state the formula expressing the relationship between matter and energy.

3.33 Chemical Energy

- 32. To define "endothermic reaction."
- 33. To define "exothermic reaction."
- 34. Given a thermal equation, to identify whether an exothermic or endothermic reaction is involved.

3.34 Comparisons

- 35. To arrange qualitatively, in order of increasing relative quantity, the amounts of energy associated with the following changes:
 - a) physical,
 - b) chemical,
 - c) nuclear.

TOTAL TEACHING TIME 100 hours

3.30 Energy

3.31 Forms

- 27. To list several forms of energy.
- 28. To define "potential energy."
- 29. To define "kinetic energy."

3.32 Conservation

- 30. To give some examples of conservation of energy.
- 31. To state the formula expressing the relationship between matter and energy.

3.33 Chemical Energy

- 32. To define "endothermic reaction."
- 33. To define "exothermic reaction."
- 34. Given a thermal equation, to identify whether an exothermic or endothermic reaction is involved.

Note: Objectives 32, 33, 34 may be integrated into Unit 5.

TOTAL TEACHING TIME 150 hours

4.00 ATOMIC THEORY

4.10 Concept of Model

6. To define the concept of "model."

4.20 The Particle Model of Matter

7. To deduce from the behaviour of gases, the hypothesis of the particle or molecular nature of matter.

4.21 Avogadro's Hypothesis

9. To state Avogadro's hypothesis.
10. To quantitatively determine the ratio of two volumes of gases reacting together.
11. To explain the SIMPLE ratios of gases reacting together, using Avogadro's hypothesis.

4.22 Molecules and Atoms

12. To define "atom."

4.24 Molecular Models

16. To build models of molecules already studied.

TOTAL TEACHING TIME 100 hours

4.00 ATOMIC THEORY

4.10 Concept of Model

6. To define the concept of "model."

Note: This Objective may be taught with Objective 1 of Unit 3.

4.22 Molecules and Atoms

12. To define "atom" and "molecule."

4.24 Molecular Models

16. To build models of molecules already studied.

Note: To give a conceptual definition of elements and compounds.

TOTAL TEACHING TIME 150 hours

4.25 Symbols and Formulas

17. To write the chemical symbols for the first 18 elements.
18. To identify the first 18 elements from their symbols.
19. To write the formula for a familiar compound from its name.
20. To write the name of a familiar compound from its formula.
21. To identify the number of each kind of atom present in a molecular formula.

4.26 Formulas: Molecular and Structural

22. To define "molecular formula."
23. To define "structural formula."
24. To distinguish between a molecular and a structural formula.

4.27 Mole and Avogadro's Number

25. To define "mole."
26. To establish the correlation between mole and Avogadro's number.
(N_A)

4.28 Molar Masses: a) of molecules
b) of atoms

27. To define "relative molar mass."
28. To define "molecular mass."
29. To define "molecular molar mass."
30. To distinguish between molecular molar mass and molecular mass.

TOTAL TEACHING TIME 100 hours

4.25 Symbols and Formulas

17. To write the chemical symbols for the first 18 elements.
18. To identify the first 18 elements from their symbols.
19. To write the formula for a familiar compound from its name.
20. To write the name of a familiar compound from its formula.
21. To identify the number of each kind of atom present in a molecular formula.

4.26 Formulas: Molecular and Structural

22. To define "molecular formula."
23. To define "structural formula."
24. To distinguish between a molecular and a structural formula.

4.27 Mole and Avogadro's Number

25. To define "mole."
26. To establish the correlation between mole and Avogadro's number.
(N_A)

4.28 Molar Masses: a) of molecules
b) of atoms

29. To define "molecular molar mass."

TOTAL TEACHING TIME 150 hours

31. To define "atomic molar mass."
32. To distinguish between molar mass of an atom and atomic mass.
33. To calculate the molecular molar mass of a substance from its formula and a table of atomic molar masses.
35. To calculate, from the formula of a substance:
 - a) the number of molecular moles corresponding to a given mass of this substance and vice versa;
 - b) the number of molecules;
 - c) the number of moles of each kind of atom present.

4.29 Relative Molecular Molar Mass

36. To compare experimentally the relative masses of equal volumes of gases.

TOTAL TEACHING TIME 100 hours

31. To define "atomic molar mass."
33. To calculate the molecular molar mass of a substance from its formula and a table of atomic molar masses.

TOTAL TEACHING TIME 150 hours

5.00 CHEMICAL REACTIONS AND STOICHIOMETRY

5.10 Chemical Reactions

1. To name 3 ways of identifying a chemical change.
2. To give a conceptual definition of a chemical change.
3. To identify 2 fundamental hypotheses proposed by the atomic theory to explain the characteristic properties of individual substances (Dalton).

5.20 Chemical Equations

5.21 Writing Equations

4. To translate a verbal description of an equation into a chemical equation.
5. To describe the changes in a given chemical equation by indicating the substances present, the number of atoms in each molecule and the number of molecules of each substance involved in the reaction.
6. Given a chemical equation, to identify the reactants and the products.

5.22 Balancing Equations

7. To balance simple chemical equations, taking into account these principles:
 - a) conservation of mass,
 - b) conservation of atoms,
 - c) non-conservation of molecules.

TOTAL TEACHING TIME 100 hours

5.00 CHEMICAL REACTIONS AND STOICHIOMETRY

5.10 Chemical Reactions

1. To name 3 ways of identifying a chemical change.
2. To give a conceptual definition of a chemical change.

5.20 Chemical Equations

5.21 Writing Equations

4. To translate a verbal description of an equation into a chemical equation.
5. To describe the changes in a given chemical equation by indicating the substances present, the number of atoms in each molecule and the number of molecules of each substance involved in the reaction.
6. Given a chemical equation, to identify the reactants and the products.

5.22 Balancing Equations

7. To balance simple chemical equations, taking into account these principles:
 - a) conservation of mass,
 - b) conservation of atoms,
 - c) non-conservation of molecules.

TOTAL TEACHING TIME 150 hours

5.23 Calculations

8. To calculate, given a balanced chemical equation, the stoichiometric quantities involved in the following conversions or proportions:

- a) mass _____ mass
- b) mass _____ mole
- c) mole _____ mole

5.30 Law of Conservation

5.31 Of Mass:

- 9. To state the law of conservation of mass from experimental data.
- 10. To apply the law of conservation of mass to the solution of problems having as an unknown variable the mass of a reactant or a product.

5.32 Of Energy:

- a) Principle of proportionality

- 11. To formulate a principle on the relationship between the quantity of reactant and the quantity of energy liberated or absorbed:
 - a) during a change of state,
 - b) during a chemical reaction.

TOTAL TEACHING TIME 100 hours

5.23 Calculations

8. To calculate, given a balanced chemical equation, the stoichiometric quantities involved in the following conversions or proportions:

- a) mass _____ mass
- c) mole _____ mole

5.30 Law of Conservation

5.31 Of Mass:

- 9. To state the law of conservation of mass from experimental data.
- 10. To apply the law of conservation of mass to the solution of problems having as an unknown variable the mass of a reactant or a product.

5.32 Of Energy:

- a) Principle of proportionality

- 11. To formulate a principle on the relationship between the quantity of reactant and the quantity of energy liberated or absorbed:
 - a) during a change of state,
 - b) during a chemical reaction.

TOTAL TEACHING TIME 150 hours

TOTAL TEACHING TIME 100 hours

b) Principle of reversibility

12. To compare the quantity of energy liberated by a given mass of a substance during a change of state to the quantity of energy absorbed by the same mass of this substance during a reverse change of state.
13. To compare the quantity of energy liberated by a given mass of a substance while it is being formed to the quantity of energy absorbed by the same mass of this substance during decomposition.
14. To deduce an energy principle from the 2 comparisons given above.

Note: Objectives 32, 33, 34 of Unit 3
could be integrated into this
section.

TOTAL TEACHING TIME 150 hours

TOTAL TEACHING TIME 100 hours

6.00 THE KINETIC MOLECULAR THEORY OF
MATTER

6.10 The Gas Phase

6.11 Pressure:

- a) Barometers and manometers
 - b) Reference pressure
 - c) Partial pressure
 - d) Boyle's law
-
1. To define the pressure of a gas as a function of the number of collisions.
 2. To explain the principle of mercury and aneroid barometers.
 4. To read atmospheric pressure on a mercury barometer, or a diagram of the same.
 6. To define "reference pressure."
 9. To identify qualitatively and mathematically the pressure-volume relationship of a gas.
 10. To prepare and interpret a graph of the volume of a gas as a function of its pressure.
 11. To identify, among a number of graphs, the one which describes the pressure-volume relationship of a gas.
 12. To apply the pressure-volume relationship to the solution of problems where either the pressure or the volume varies at constant temperature.

TOTAL TEACHING TIME 150 hours

6.12 Temperature:

a) Definition

13. To distinguish between temperature and heat.

b) Reference temperature

14. To define "reference temperature."

c) Absolute temperature

15. To prepare and interpret a graph of the pressure-temperature relationship of a gas.

16. To determine the temperature at which the pressure becomes zero.

17. To identify qualitatively and mathematically the pressure-temperature relationship of a gas.

18. To apply the pressure-temperature relationship of a gas to the solution of problems where the temperature varies at constant volume.

d) Celsius and Kelvin scales

20. To convert readings on the Celsius scale to degrees Kelvin and vice versa.

TOTAL TEACHING TIME 100 hours

FIN

TOTAL TEACHING TIME 150 hours

e) Charles' law

21. To prepare and interpret a graph of the volume-temperature relationship of a gas.
22. To identify qualitatively and mathematically the volume-temperature relationship of a gas.
23. To apply the volume-temperature relationship (Charles' law) to the solution of problems where the temperature (K) varies at constant pressure.

6.13 Molar Volume

26. To determine experimentally the approximate value of the molar volume of a gas at room temperature and pressure, using a method that will make it possible to ignore variations in volume due to temperature and pressure.
28. To define the molar volume of a gas.
30. To calculate, given a balanced chemical equation, the stoichiometric quantities involved in the following conversions:

mass _____ volume
volume _____ volume
volume _____ mole

TOTAL TEACHING TIME 100 hours

TOTAL TEACHING TIME 150 hours

TOTAL TEACHING TIME 100 hours

6.14 The Kinetic Molecular Theory

32. To name the main points of the kinetic molecular theory.
33. To explain the states of matter in terms of the kinetic molecular theory.
34. To rank the velocity of the molecules of different gases according to their respective molecular sizes.
35. To name the relationship between the kinetic energies of molecules of different gases at a given temperature.

6.20 Changes of State

37. To prepare, from experimental data, a graph showing the heating curve of a pure substance.
38. To identify, from the heating curve of a pure substance, its melting and boiling points.
39. To write an equation involving a change of state.
40. To read an equation involving a change of state.

6.21 Solid ———— Liquid:

a) Heat of fusion

41. To define "joule."
42. To define "heat of fusion."
43. To determine experimentally and mathematically the heat of fusion of a substance.

TOTAL TEACHING TIME 150 hours

48. To state a hypothesis that would explain why temperature remains constant during a change of state.

b) Heat of solidification

49. To define "heat of solidification."

6.22 Liquid ————— Gas:

a) Heat of vaporization

b) Heat of condensation

51. To define "heat of vaporization."

52. To define "heat of condensation."

53. To calculate the energy required to vaporize or condense a given mass of a substance, given its heat of vaporization or condensation.

b) Evaporation/boiling

57. To distinguish between evaporation and boiling.

TOTAL TEACHING TIME 100 hours

TOTAL TEACHING TIME 150 hours

7.00 SOLUTIONS

7.10 Solubility

1. To give an operational definition of "solubility."
2. To distinguish between a solvent and a solute.
3. To name 2 factors which influence solubility.
4. To describe how the solvent and solute affect the degree of solubility of a solution.
5. To describe the effect of temperature on the solubility of solids in a liquid and of gases in a liquid.
6. Given a graph of the solubility of several substances, to identify the most soluble and least soluble solute.
7. To describe:
 - a) a saturated solution,
 - b) an unsaturated solution.
8. To prepare:
 - a) a saturated solution,
 - b) an unsaturated solution.

7.11 Dissolution

9. To name the different solvent-solute combinations likely to form a solution.
10. To explain the solubility-temperature graph of a solid.

TOTAL TEACHING TIME 100 hours

7.00 SOLUTIONS

7.10 Solubility

1. To give an operational definition of "solubility."
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7.11 Dissolution

9. To name the different solvent-solute combinations likely to form a solution.
10. To explain the solubility-temperature graph of a solid.

TOTAL TEACHING TIME 150 hours

7.20 Molar Concentration (Molarity)

11. To define "molar concentration."
12. To prepare different types of solid-liquid and liquid-liquid solutions of different molar concentrations.
13. To explain the formula that expresses the qualitative and quantitative content of a solution.
14. To calculate the molar concentration of a solution, given the volume of solution, the number of moles of solute or its mass in grams and vice versa.

7.21 Common Concentrations

(Ref. Guide des Unités SI Sec. 574, CRIQ, Québec, 1982)*

15. To name everyday situations where the following concentration ratios are used:
 - a) Mass/volume
 - b) Mass/mass
 - c) Volume/volume
 - d) a, b, c, expressed as percentages (%).

7.40 Properties

7.41 Electrical Conductivity of Solutions

18. To define "electrolyte" and "non-electrolyte."

TOTAL TEACHING TIME 100 hours

7.20 Molar Concentration (Molarity)

11. To define "molar concentration."
13. To explain the formula that expresses the qualitative and quantitative content of a solution.

7.21 Common Concentrations

(Ref. Guide des Unités SI Sec. 574, CRIQ, Québec, CRIQ 1982)*

15. To name everyday situations where the following concentration ratios are used:
 - a) Mass/volume
 - b) Mass/mass
 - c) Volume/volume
 - d) a, b, c, expressed as percentages (%).

7.40 Properties

7.41 Electrical Conductivity of Solutions

18. To define "electrolyte" and "non-electrolyte."

* This guide book is available in English.

TOTAL TEACHING TIME 150 hours

19. To distinguish between an electrolyte and a nonelectrolyte.
20. To define "anode," "cathode," "cation" and "anion." (Ref. 8.10)

7.42 Electrolysis

21. To identify an operational criterion to distinguish between a weak and a strong electrolyte.
22. To formulate a hypothesis to explain the difference in conductivity between a strong and weak electrolyte.
23. To identify 3 factors responsible for the electrical conductivity of solutions.

7.43 Precipitation Reactions In Aqueous Solutions

24. To recognize a precipitation reaction.
25. To balance an ionization equation using a table of common ions and the conservation of charge principle.
30. To calculate, given the concentration of an ionic solute, the concentration of ions present in an aqueous solution of this solute.

TOTAL TEACHING TIME 101 hours

19. To distinguish between an electrolyte and a nonelectrolyte.
20. To define "cation" and "anion." (Ref. 8.10)

7.42 Electrolysis

21. To identify an operational criterion to distinguish between a weak and a strong electrolyte.
22. To formulate a hypothesis to explain the difference in conductivity between a strong and weak electrolyte.
23. To identify 3 factors responsible for the electrical conductivity of solutions.

7.43 Precipitation Reactions In Aqueous Solutions

24. To recognize a precipitation reaction.

TOTAL TEACHING TIME 150 hours

8.00 STRUCTURE OF THE ATOM AND THE
PERIODIC TABLE

8.10 Model of the Nuclear Atom

1. To describe Thomson's atomic model.
2. To describe Rutherford's nuclear atomic model.
3. To identify :
 - a) the charge of an electron,
 - b) the charge of a proton.
4. To define "ion."
5. To define "neutron."
6. To formulate hypotheses on the attraction or repulsion of electrically charged particles.
7. To prepare a graph of electrostatic force as a function of distance, given a number of values for a variable "r."

8.20 Characteristics of the Nuclear Atom

8.21 The Mass of an Atom and Its Constituents

9. To define the following by naming two properties for each:
 - a) electron
 - b) proton
 - c) neutron.

TOTAL TEACHING TIME 100 hours

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PERIODIC TABLE

8.10 Model of the Nuclear Atom

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 - a) the charge of an electron,
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5. To define "neutron."
5. To formulate hypotheses on the attraction or repulsion of electrically charged particles.

8.20 Characteristics of the Nuclear Atom

8.21 The Mass of an Atom and Its Constituents

9. To define the following by naming two properties for each:
 - a) electron
 - b) proton
 - c) neutron.

Note: To distinguish quantitatively the order of magnitude of the mass of the proton, neutron and electron.

TOTAL TEACHING TIME 150 hours

8.22 Size of the Atom

11. To identify the size of the diameter of the atom and that of the nucleus.

8.23 Atomic Number

12. To define "atomic number."

8.24 Mass Number

13. To define "mass number" or "number of nucleons."

8.25 Isotopes

14. To define "isotopes."
15. To indicate the number of protons, neutrons and electrons for a given isotope of an element with a known mass number and atomic number.
16. To name some fields of application for the isotopes of certain elements (I, Co, P, Na).

8.26 Nuclear Reactions

17. To describe a nuclear reaction.
18. To write correctly the equation for a balanced nuclear reaction.

TOTAL TEACHING TIME 100 hours

8.23 Atomic Number

12. To define "atomic number."

8.24 Mass Number

13. To define "mass number" or "number of nucleons."

8.25 Isotopes

14. To define "isotopes."
15. To indicate the number of protons, neutrons and electrons for a given isotope of an element with a known mass number and atomic number.
16. To name some fields of application for the isotopes of certain elements (I, Co, P, Na).

8.26 Nuclear Reactions

17. To describe a nuclear reaction.

Note: Within the context of this section the controversy over nuclear energy could be discussed.

TOTAL TEACHING TIME 150 hours

8.30 Chemical Families and Periodicity

19. To define "periodicity."
20. To identify the periodicity of the periodic numbers 2, 8, 18.
21. To state the periodic law.

8.31 Classification

22. To distinguish between metals and nonmetals from their physical properties.
23. To define "chemical families" in terms of chemical activity.
24. To identify the noble gases, the alkali and the halogens by their position in the periodic table.
25. To define "period."

8.32 Periodic Properties:

- a) chemical activity,
 - b) atomic mass,
 - c) electronegativity,
 - d) ionization energy.
26. To list the properties by which you identify a family (group) or period of the periodic table.
 27. To define "electronegativity."
 29. To identify the trend in the following properties for a given family (group) in the periodic table:
 - a) melting point,
 - b) boiling point,
 - c) chemical activity,
 - d) electronegativity,
 - e) atomic mass.

TOTAL TEACHING TIME 100 hours

8.31 Classification

22. To distinguish between metals and nonmetals from their physical properties.
23. To define "chemical families" in terms of chemical activity.
24. To identify the noble gases, the alkali and the halogens by their position in the periodic table.
25. To define "period."

TOTAL TEACHING TIME 150 hours

9.00 CHEMICAL BONDING

9.10 Electron Configuration

9.11 Electron Shells and Energy Levels

1. To define "electron shell."
2. To define "energy level."
3. To determine the basic electron configuration (Bohr model) of the atoms of the first 20 elements.

9.20 Principles of Stability

4. To identify the hypothesis that explains the stability of the noble gases.
5. To compare the electron behaviour of atoms of elements in groups 1, 2, 6 and 7 (in particular) to that of the noble gases.
6. To distinguish between the electron configuration of the elements of families 1, 2, ... 6, 7 and the closest noble gas.
7. To identify the charge associated with the single-atom ions of the elements of these particular groups.
8. To write the formula for the halides, oxides and hydrides of each of the first twenty (20) elements, given the group to which each element belongs.

9.30 Valence Electrons

9. To define "valence electron."

TOTAL TEACHING TIME 100 hours

9.00 CHEMICAL BONDING

9.10 Electron Configuration

9.11 Electron Shells and Energy Levels

1. To define "electron shell."
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7. To identify the charge associated with the single-atom ions of the elements of these particular groups.

9.30 Valence Electrons

9. To define "valence electron."

TOTAL TEACHING TIME 150 hours

10. To calculate, given the atomic number of an element, the number of valence electrons of this element.
11. To depict, using Lewis' structures, the valence electrons of the first 20 elements.
12. To predict, given the group to which an element belongs:
 - a) its probable physical properties;
 - b) the formula of its hydride, oxide and halide;
 - c) the number of electrons involved in simple chemical reactions.

9.40 Chemical Bonds

9.41 Ionic

13. To define ionic bond in terms of difference in electronegativity.

9.42 Covalent

14. To define covalent bond in terms of the difference in electronegativity.
15. To depict these two types of bonds using Lewis' structural diagrams.
16. To name two methods of attaining the noble gas structure in a system of two or more atoms.

TOTAL TEACHING TIME 100 hours

10. To calculate, given the atomic number of an element, the number of valence electrons of this element.
11. To depict, using Lewis' structures, the valence electrons of the first 20 elements.
12. To predict, given the group to which an element belongs:
 - a) its probable physical properties;
 - b) the formula of its hydride, oxide and halide;
 - c) the number of electrons involved in simple chemical reactions.

9.40 Chemical Bonds

9.41 Ionic

13. To define ionic bond in terms of electron transfer.

9.42 Covalent

14. To define covalent bond in terms of an electron transfer.
15. To depict these two types of bonds using Lewis' structural diagrams.

TOTAL TEACHING TIME 150 hours

20. To predict the bond type (ionic, covalent) between two atoms, based on the difference in electronegativity.
21. To identify the Lewis structure of the halides and oxides of the first 20 elements, including the possible homonuclear structures.
22. To identify examples of single, double and triple bonds.

9.90 Molecular Geometry

23. To construct, using commercial models, a minimum of two molecules for each of the following molecular shapes:
 - a) linear,
 - b) angular,
 - c) triangular planar,
 - d) pyramidal,
 - e) tetrahedral.
24. To identify from a group of molecules, a given molecular structure.

TOTAL TEACHING TIME 100 hours

TOTAL TEACHING TIME 150 hours

10.00 ACIDS AND BASES

10.10 Properties of Acids and Bases

1. To give an operational definition for "acid."
2. To give an operational definition for "base."

10.20 Explanation of the Properties of Acids and Bases

3. To formulate a conceptual definition of an acid and a base according to the Arrhenius theory.
4. To write ionization equations for acids or bases according to this theory.
5. To write the dissociation equation for water, in terms of aqueous ions.
6. To indicate the molar concentration of H^+ and OH^- ions in pure water.
7. To make operational distinctions between a strong and a weak acid.

10.22 Neutralization

9. To describe briefly how an acid and a base react with each other.
10. To write the net ionic equation for neutralization.
11. To recognize a neutralization reaction.

TOTAL TEACHING TIME 100 hours

10.00 ACIDS AND BASES

10.10 Properties of Acids and Bases

1. To give an operational definition for "acid."
2. To give an operational definition for "base."

10.20 Explanation of the Properties of Acids and Bases

3. To formulate a conceptual definition of an acid and a base according to the Arrhenius theory.
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5. To write the dissociation equation for water, in terms of aqueous ions.
6. To indicate the molar concentration of H^+ and OH^- ions in pure water.
7. To make operational distinctions between a strong and a weak acid.

10.22 Neutralization

9. To describe briefly how an acid and a base react with each other.
10. To write the net ionic equation for neutralization.
11. To recognize a neutralization reaction.

TOTAL TEACHING TIME 150 hours

10.30 The pH Scale

13. To find the molar concentration of a solution where the H^+ ions $= 10^{-1}$ mol/l or the pH = 1.
14. To determine the pH of a solution, given the H^+ ion concentration.
15. To determine the H^+ concentration of a solution from its pH.
16. To establish a parallel between the H^+ ion concentration scale (10^{-1} to 10^{-14} mol/l), or the pH value (1 to 14), and the acidic, basic and neutral properties of a solution.
17. To determine whether a solution is acidic, basic or neutral, from its H^+ ion concentration or its pH.
18. To describe several simple systems in which the pH balance plays an important role.

10.40 Indicators

19. To determine, using indicators, whether certain household products are acidic or basic.
20. To identify several household indicators.

TOTAL TEACHING TIME 100 hours

10.30 The pH Scale

16. To establish a parallel between the pH scale (1 to 14) and the acidic, basic or neutral properties of a solution.
17. To determine whether a solution is acidic, basic or neutral, from its pH.
18. To describe several simple systems in which the pH balance plays an important role.

10.40 Indicators

19. To determine, using indicators, whether certain household products are acidic or basic.
20. To identify several household indicators.

TOTAL TEACHING TIME 150 hours

TOTAL TEACHING TIME 100 hours

11.00 CHEMICAL ASPECT OF THE ENVIRONMENT*

11.10 General Environmental Considerations

a) Equilibrium and natural cycles.

1. To define "community."
2. To define "food pyramid."
3. To describe, using an example, the nutritional, reproductive and protective links which unite the members of a natural community.
4. To describe how the numerical balance is maintained in a community over a long period of time.
5. To describe the equilibrium in the relationship:
organism ———— environment
6. To describe the effects of the specialization of species and communities on the environment.

b) Natural cycles

7. To state the three major subdivisions of the earth's environment.
8. To describe the water cycle.
9. To describe the rock cycle of mineral substances.
10. To describe and draw a diagram of the contribution of each of the 3 subdivisions of the environment to the nutrition of living beings.

* In this section a choice should be made of one of 3 topics: 11.20, 11.30 or 11.40.

TOTAL TEACHING TIME 150 hours

TOTAL TEACHING TIME 100 hours

c) The chemical cycles

11. To describe and draw a diagram of the oxygen cycle.
12. To describe and draw a diagram of the carbon cycle.
13. To describe and draw a diagram of the nitrogen cycle.
14. To describe the importance of bacteria in the nitrogen cycle.
15. To describe the part played by the decomposition of dead organisms in the atmospheric, lithospheric and hydrospheric cycles.

11.12 Pollution

16. To name four characteristics of pollution.
17. To describe the horizontal profiles of pollution.
18. To explain the fundamental vertical profile of pollution.

11.13 The Effects of Pollution

a) Social values

19. To name three effects of pollution on social values.

b) Economic values

20. To name three effects of pollution on economic values.

TOTAL TEACHING TIME 150 hours

11.20 The Earth's Atmosphere

11.21 The Natural Composition of Air

21. To draw up a quantitative list of the constituents of clean dry air by percentages.
22. To establish the biological importance of air for respiration.
23. To name 3 physical properties, 3 chemical properties and 3 uses of oxygen.
24. To name 3 physical properties, 3 chemical properties and 3 uses of nitrogen.

11.22 Atmospheric Pollutants

a) Nature

25. To name 10 atmospheric pollutants.

b) Sources

26. To identify 2 sources for each of these pollutants.

c) Effects

27. To determine, for each pollutant, its effects on:
 - a) living beings,
 - b) plants,
 - c) the man-made environment.

TOTAL TEACHING TIME 100 hours

11.20 The Earth's Atmosphere

11.21 The Natural Composition of Air

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27. To determine, for each pollutant, its effects on:
 - a) living beings,
 - b) plants,
 - c) the man-made environment.

TOTAL TEACHING TIME 150 hours

a) Detection

28. To describe an appropriate detection method for each pollutant.
29. To name 2 natural means by which the air cleanses itself.
30. To name some artificial means for cleansing the air.
31. To name 2 different ways of describing the concentration of pollutants.
32. To distinguish between minimum accepted concentration and critical concentration.
33. To list the critical concentrations of the 10 pollutants already mentioned.

11.23 Personal "Anti-Pollution" Contribution

34. To identify 5 personal and social habits that are a source of air pollution.
35. To identify 5 personal ways of contributing to air purification.

11.30 The Aquatic Environment (Hydrosphere)

11.31 The Importance of Water Resources

a) Uses

36. To describe, using examples, the many uses of water.
37. To estimate the average amount of water consumption for industrial and domestic use in litres per person per day.

TOTAL TEACHING TIME 100 hours

d) Detection

28. To describe an appropriate detection method for each pollutant.
29. To name 2 natural means by which the air cleanses itself.
30. To name some artificial means for cleansing the air.
31. To name 2 different ways of describing the concentration of pollutants.
32. To distinguish between minimum accepted concentration and critical concentration.
33. To list the critical concentrations of the 10 pollutants already mentioned.

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11.30 The Aquatic Environment (Hydrosphere)

11.31 The Importance of Water Resources

a) Uses

36. To describe, using examples, the many uses of water.
37. To estimate the average amount of water consumption for industrial and domestic use in litres per person per day.

TOTAL TEACHING TIME 190 hours

b) Current and future needs

38. To describe briefly the influence of the following five factors on future demands for water: population, nature of the economy, technology, social habits and government decisions.

c) Current and future availability

39. To estimate from statistics the available water resources in Québec in billions of litres and in relation to the demand (in 1980) in billions of litres per year.

11.32 Natural Composition of Water

a) Natural constituents

40. To name the main constituents of river water.
41. To name the reagents used to detect the following ions: Ca^{2+} , Cl^- , Mg^{2+} , CO_3^{2-} .
42. To describe a method for qualitatively measuring the concentration of O_2 in water.
44. To distinguish between "natural water" and "chemically pure water."
45. To distinguish between hard and soft water.

TOTAL TEACHING TIME 100 hours

b) Current and future needs

38. To describe briefly the influence of the following five factors on future demands for water: population, nature of the economy, technology, social habits and government decisions.

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42. To describe a method for qualitatively measuring the concentration of O_2 in water.
44. To distinguish between "natural water" and "chemically pure water."
45. To distinguish between hard and soft water.

TOTAL TEACHING TIME 150 hours

- b) Properties and composition of domestic water

47. To name some of the properties of drinking water.

11.33 Water Pollutants

- a) Nature

49. To name 10 types of water pollutants.

- b) Source

50. To identify, for each of these types of pollutants, 2 domestic or industrial sources.

- c) Effects

51. To determine, for each of these types of pollutants, one effect on:

- a) living beings,
- b) plants,
- c) ecology,
- d) the man-made environment.

- d) Detection and norms

52. To describe a method of detection appropriate to each of these kinds of pollutants.

53. To state certain criteria or norms for the disposal of waste.

54. To classify polluted and non-polluted water on the basis of these criteria.

TOTAL TEACHING TIME 100 hours

- b) Properties and composition of domestic water

47. To name some of the properties of drinking water.

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50. To identify, for each of these types of pollutants, 2 domestic or industrial sources.

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- a) living beings,
- b) plants,
- c) ecology,
- d) the man-made environment.

- d) Detection and norms

52. To describe a method of detection appropriate to each of these kinds of pollutants.

53. To state certain criteria or norms for the disposal of waste.

54. To classify polluted and non-polluted water on the basis of these criteria.

TOTAL TEACHING TIME 150 hours

e) Purification and control:

- by natural means,
- by artificial means.

55. To name 2 natural means by which water cleanses itself.

56. To describe, as examples of artificial means of cleansing water:

- a) four physical methods
- b) six chemical methods.

57. To distinguish between the chemical properties of $F_2(g)$ and $F^-(aq)$.

58. To name certain compounds of chlorine and fluorine suitable for the chemical treatment of water.

11.34 Personal "Anti-Pollution" Contribution

59. To identify 5 personal habits as sources of water pollution.

60. To describe a five-point program of action as a personal contribution to water purification.

11.40 Terrestrial Environment (Lithosphere)

11.41 Pollutants

a) Nature

61. To distinguish between organic and inorganic types of pollutants.

TOTAL TEACHING TIME 100 hours

e) Purification and control:

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- by artificial means.

55. To name 2 natural means by which water cleanses itself.

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11.40 Terrestrial Environment (Lithosphere)

11.41 Pollutants

a) Nature

61. To distinguish between organic and inorganic types of pollutants.

TOTAL TEACHING TIME 150 hours

b) Sources

- 62. To distinguish between biodegradable and elementary substances.
- 63. To name 5 domestic or industrial pollutants.

c) Purification

- 64. To name 3 methods for controlling pollution caused by solid waste.
- 65. To discuss the relative merits of each of these methods.

11.42 Personal "Anti-Pollution" Contribution

- 66. To identify 5 personal and social habits that contribute to pollution.
- 67. To describe an anti-pollution program consisting of 10 ways of reducing one's personal contribution to solid-waste pollution.

TOTAL TEACHING TIME 100 hours

b) Sources

- 62. To distinguish between biodegradable and elementary substances.
- 63. To name 5 domestic or industrial pollutants.

c) Purification

- 64. To name 3 methods for controlling pollution caused by solid waste.
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- 67. To describe an anti-pollution program consisting of 10 ways of reducing one's personal contribution to solid-waste pollution.

CONTENT AND OBJECTIVES OF PHYSICS 450 AND 552

The objectives of Physics 220-452 and 220-552 are presented on the left side of the page. The suggested teaching time for these objectives was then 120 to 150 hours.

A model designed to make it possible to teach this program in 100 hours is shown on the right side of the page. Some of the objectives in certain sections have not been repeated on the right side. Therefore, it is not necessary to cover them for their own sake but only to the extent that they are needed to acquire further knowledge.

In other places, where most of the content of entire sections have become areas of flexibility, the objectives are not repeated on the right side of the page. Depending on the level of interest shown by the students, and the time and materials available, the teacher can integrate some of these special topics by doing demonstrations or by having the students do research. This approach could apply to a topic such as optics, particularly the section dealing with the particle or wave model of light.

In a general way, the criteria mentioned in the preceding pages have been useful in establishing these areas of flexibility. It is up to teachers, however, to make any necessary adjustments by following the guidelines suggested at the beginning of this document.

PHYSICS 452

TOTAL TEACHING TIME 150 hours

A- BASIC CONCEPTS

1. Time, Space, Matter and Measurements

- . Definition and measurement of time, space, matter; units.
- . Limits of measurements: concept of error; significant figures.

LABORATORY

- . Measurement of distance.
- . Short intervals of time.
- . Precision and limits of measurements.

2. Mathematical Instruments*

- . Mathematical relationships: direct and inverse proportions, proportionality constant, slopes, power laws, similar figures, the inverse square relation, equations, functions, graphs.
- . Interpolation and extrapolation.
- . Trigonometric functions: sine, cosine and tangent.
- . Graph of a direct proportion.
- . Analysis of an experiment.

* This section may be covered as needed.

TOTAL TEACHING TIME 100 hours

A- BASIC CONCEPTS

The concepts in this section can be covered as needed; that is, they can be incorporated whenever they are necessary for the acquisition of additional knowledge. The same applies in the section pertaining to mathematical instruments.

TOTAL TEACHING TIME 150 hours

B- OPTICS

1. Geometrical Optics

- . Sources of light; general properties of light.
- . Reflection and images; shadows; beams, pencils and rays of light; laws of reflection; plane and parabolic mirrors; projectors and astronomical telescopes; real and virtual images.
- . Refraction; experiments on the angles of refraction; Snell's law; relative and absolute indices of refraction; the passage of light from one medium to another; reversibility; total internal reflection; refraction by prisms; dispersion.
- . Convergence by a set of prisms; lenses; real images formed by lenses.

LABORATORY

- . Qualitative experiments on general concepts.
- . Reflection from a plane mirror.
- . Refraction.
- . Images formed by a converging lens.

TOTAL TEACHING TIME 100 hours

B- OPTICS

1. Geometrical Optics

- . Sources of light; general properties of light.
- . Reflection and images; shadows; beams, pencils and rays of light; laws of reflection; plane and parabolic mirrors; projectors and astronomical telescopes; real and virtual images.
- . Refraction; experiments on the angles of refraction; Snell's law; relative and absolute indices of refraction; the passage of light from one medium to another; reversibility; total internal reflection; refraction by prisms; dispersion.
- . Convergence by a set of prisms; lenses; real images formed by lenses.

LABORATORY

- . Qualitative experiments on general concepts.
- . Reflection from a plane mirror.
- . Refraction.
- . Images formed by a converging lens.

TOTAL TEACHING TIME 150 hours

2. The Particle Model of Light

- . Reflection, refraction, intensity of illumination, pressure of light, absorption and heating, speed of light and the theory of refraction, drawbacks of the particle theory.

- . Concept of model.

LABORATORY

- . Refraction of particles.

3. The Wave Model of Light

- . Pulses and waves, waves on coil springs, superposition of waves, reflection and transmission; water waves; straight and circular pulses; reflection; refraction; dispersion and refraction of waves; speed of propagation.

- . Periodic waves.

- . Interference produced by two point sources; nodal lines; wavelengths; source separation, angles, phase.

- . Young's experiment: Interference of light waves; colours and wavelengths of light; diffraction of light by single and double slits.

LABORATORY

- . Waves on a coil spring
- . Pulses on the surface of water
- . Periodic waves
- . Refraction of waves
- . Waves and obstacles
- . Waves from two point sources
- . Interference and phase
- . Young's experiment
- . Diffraction of light by a single slit.

TOTAL TEACHING TIME 100 hours

TOTAL TEACHING TIME 150 hours

C- MECHANICS

1. Kinematics

- . Scalar distances and vector displacements.
- . Average speed, instantaneous speed, velocity vector.
- . Average acceleration, instantaneous acceleration, vector acceleration.
- . Description of motion: frames of reference, trajectories and vector components.
- . Analysis of velocity-time, position-time and acceleration-time graphs: Slope, tangent, area under a curve.
- . Uniform rectilinear motion and uniformly varied rectilinear motion; formulas.
- . Motion at variable speed and constant acceleration.

LABORATORY

- . Motion: variable speed and acceleration.
- . Motion: variable speed and constant acceleration.

TOTAL TEACHING TIME 100 hours

C- MECHANICS

1. Kinematics

- . Scalar distances and vector displacements.
- . Average speed, instantaneous speed, velocity vector.
- . Average acceleration, instantaneous acceleration, vector acceleration.
- . Description of motion: frames of reference, trajectories and vector components.
- . Analysis of velocity-time, position-time, and acceleration-time graphs: Slope, tangent, area under a curve.
- . Uniform rectilinear motion and uniformly varied rectilinear motion; formulas.
- . Motion at variable speed and constant acceleration.

LABORATORY

- . Motion: variable speed and acceleration.
- . Motion: variable speed and constant acceleration.

TOTAL TEACHING TIME 150 hours

2. Dynamics

- . Relationship between force and motion.
- . Changes in velocity due to the action of a constant force; acceleration.
- . Inertial mass and gravitational mass.
- . Newton's law; dynamic method for measuring force; units.
- . Vector nature of forces; resultant and equilibrant forces; systems in equilibrium.
- . Weight; earth's gravitational field; free fall and motion of a projectile (vector nature of Newton's law; trajectory).
- . Circular motion; centripetal and centrifugal forces; satellites.
- . Universal gravitation and the solar system; different planetary systems; Kepler's laws; universal gravitation.

LABORATORY

- . Changes in velocity for a constant force.
- . The influence of force and mass on acceleration.
- . Inertial and gravitational mass.
- . Forces on a ball in flight.
- . Projectiles.
- . Centripetal force.
- . Law of equal areas.

TOTAL TEACHING TIME 100 hours

2. Dynamics

- . Relationship between force and motion.
- . Changes in velocity due to the action of a constant force; acceleration.
- . Newton's law; dynamic method for measuring force; units.
- . Vector nature of forces; resultant and equilibrant forces; systems in equilibrium.
- . Weight; earth's gravitational field; free fall and motion of a projectile (vector nature of Newton's law; trajectory).
- . Circular motion; centripetal and centrifugal forces; satellites.
- . Universal gravitation.

LABORATORY

- . Changes in velocity for a constant force.
- . The influence of force and mass on acceleration.
- . Projectiles.
- . Centripetal force.

PHYSICS 552

TOTAL TEACHING TIME 150 hours

5. Energy and Its Conservation

- . Impulse; momentum; the law of conservation of momentum.
- . Work; kinetic energy; conservation of kinetic energy in elastic collisions; loss of kinetic energy in a frictional interaction.
- . Potential energy of a spring; potential gravitational energy; escape energy and binding energy of satellites.
- . Thermal energy; conservation of energy.

LABORATORY

- . Momentum changes in an explosion.
- . Conservation of momentum.
- . Collision in a two-dimensional space.
- . Head-on collision.
- . Changes in potential energy.
- . Energy of a simple pendulum.

TOTAL TEACHING TIME 100 hours

5. Energy and Its Conservation

- . Impulse; momentum; the law of conservation of momentum.
- . Work; kinetic energy; conservation of kinetic energy in elastic collisions; loss of kinetic energy in a frictional interaction.
- . Potential energy of a spring; potential gravitational energy at earth's surface.
- . Conservation of energy.

LABORATORY

- . Momentum changes in an explosion.
- . Conservation of momentum.
- . Collision in a two-dimensional space.
- . Head-on collision.
- . Changes in potential energy.
- . Energy of a simple pendulum.

TOTAL TEACHING TIME 150 hours

D- ELECTRICITY AND MAGNETISM

1. Electrostatics

- . Electric charges; attraction; repulsion; insulators; conductors; induction.
- . Electrical forces; Coulomb's law; electric field; elementary charges; the Millikan experiment.

LABORATORY

- . Electrified objects.
- . Electrostatic induction.
- . The force between two charged spheres.
- . The Millikan experiment.

2. Electric Charges in Motion

- . Motion of charged particles in an electric field; electron and proton.
- . Conductivity of gases, solutions and metals.
- . Electric current: electrolytic measurement of currents; batteries; electromotive forces.
- . Electric field and potential difference.
- . Electric circuits; Ohm's law and Kirchhoff's law.

TOTAL TEACHING TIME 100 hours

D- ELECTRICITY AND MAGNETISM

2. Electrostatics

- . Electric charges; attraction; repulsion; insulators; conductors; induction.
- . Electrical forces; Coulomb's law; electric field.

LABORATORY

- . Electrified objects.
- . The force between two charged spheres.
- . The Millikan experiment.

2. Electric Charges in Motion

- . Motion of charged particles in an electric field; electron and proton.
- . Electric current: batteries; electromotive forces.
- . Electric field and potential difference.
- . Electric circuits; Ohm's law, series and parallel circuits.

TOTAL TEACHING TIME 150 hours

LABORATORY

- Potential difference.
- Charges of ions in solution.
- Electric circuits (Ohm's and Kirchoff's laws).

3. Magnetic Field

- Magnetic fields of magnets and currents; magnetic field lines; vector composition of magnetic fields.
- Forces on currents in magnetic fields; force operative between two rectilinear parallel currents; forces on moving charged particles in a magnetic field.
- Meters and motors; using magnetic fields to measure the masses of charged particles.

LABORATORY

- Pole and magnetic spectra.
- Magnetic field of a current.
- Magnetic field near a long, straight wire.
- Measurement of a magnetic field in fundamental units.
- Mass of an electron.
- Energy transferred by an electric motor.

TOTAL TEACHING TIME 100 hours

LABORATORY

- Electric circuits (Ohm's law).

3. Magnetic Field

- Magnetic fields of magnets and currents; magnetic field lines; vector composition of magnetic fields.
- Forces on currents in magnetic fields; forces on moving charged particles in a magnetic field.
- Meters and motors.

LABORATORY

- Magnetic field of a current.
- Measurement of a magnetic field in fundamental units.

TOTAL TEACHING TIME 150 hours

4. Electromagnetic Induction

- Induced current and induced electromotive force; energy of an electromotive force; relative motion.
- Magnetic flux and the law of induction; induction in cases of immobile circuits; electric fields around changing magnetic fluxes.
- Self-induction and electric oscillators; magnetic fields around changing electric fluxes.

LABORATORY

- Induction (qualitative experiments).

E- MODERN PHYSICS

1. The Rutherford Model of the Atom

- The Rutherford model of the atom; trajectories of alpha particles in the electric field of a nucleus; angular distribution of scattering.

LABORATORY

- Randomness in decay.

TOTAL TEACHING TIME 100 hours

4. Electromagnetic Induction

- Induced current and induced electromotive force; energy of an electromotive force; relative motion.
- Magnetic flux and the law of induction.
- Alternate currents, transformers.

LABORATORY

E- MODERN PHYSICS

TOTAL TEACHING TIME 150 hours

2. Photons and Matter Waves

- The graininess of light; the photon; probability of photonic bombardment; graininess and interference; photoelectric effect; mechanics of the photon; Compton effect.

- Photons and electromagnetic waves; radiation and electro-magnetic spectra; matter waves.

LABORATORY

- Simulated nuclear collisions.

3. Atomic Structure and Quantum Theory

- Franck and Hertz experiments, energy levels; excitation and emission, atomic spectra; absorption spectra; energy levels of hydrogen; wave theory of energy levels.

LABORATORY

- Spectrum of the elements.

TOTAL TEACHING TIME 100 hours

GENERAL OBJECTIVES AND RELATED CONTENT OF THE SCIENCE 412 PROGRAM

This program is intended for students who do not feel that they are capable of completing the present chemistry or physics courses.

The difficulties encountered in other science courses are often due to the way in which certain elements of the related content are presented. This program is different from the others with respect to some of the related content and, above all, in the way it is approached and the extent to which the subjects are studied. This program is not a watered-down version of the other programs and it is sufficiently demanding to be accepted as a Secondary IV program that is appropriate for some students.

The favoured teaching approach is concrete rather than abstract, practical rather than theoretical and draws inspiration from everyday examples. It is therefore up to the teacher to adopt an experimental approach in his/her teaching and to help students to identify the links that exist between elements of the suggested related content and their application in daily life. It is in this spirit and in simple language that the related content should be taught. Students should be led gradually to build up certain concepts by examining everyday occurrences, and not to study the concepts from a theoretical perspective with a view to specializing.

The original version of General Science 412 introduced three subjects: chemistry, physics and biology. The latter could be taught either first or last. In this modified version, however, the biology section has been omitted because Human Biology is compulsory in Secondary III and because the future science program for Secondary IV will comprise only chemistry and physics.

The Ministère has drawn from the original version of this program and from modified versions of this program currently being used by certain school boards in preparing this revised version of General Science 412. The following pages contain a number of topics for study that are not expressed in the form of specific objectives. In order to determine suitable objectives to pursue in studying each element of the related content, teachers should refer to the broad guidelines listed at the beginning of this document and keep in mind the following general objectives:

- To awaken the student's interest in science;
- To develop the student's sense of observation;
- To develop the student's critical skills;
- To encourage the learning of basic knowledge;
- To familiarize the student with the scientific approach, in order to foster in him/her:
 - an understanding of the true nature of the physical world;
 - sufficient independence of mind to be able to formulate personal opinions, founded in real facts;
 - a sense of the essential character of his/her contribution to society.

RELATED CONTENT

1. Basic Concepts

- What is "science"?
- The difference between science and technology;
- The scientific method: description and applications;
- Preparation and reading of graphs;
- The international system of units (simple operations);
- Distinction between mass and weight (units of measure);
- Temperature: conventional scales, conversion from degrees Kelvin to degrees Celsius;
- Atmospheric pressure, barometers.

NOTE: All of these basic concepts can be incorporated whenever necessary, that is to say, when they are required for further learning. They can also be used as subjects of laboratory experiments.

2. Matter and Energy

- Concept of the classification of matter;
- Classification: solids, liquids and gases; for example, the three states of water;
- Critical point of change; the effect of pressure;
- Properties of matter as a method of classification; various properties, including density (application of the mass/volume ratio);
- Classification of mixtures and pure substances;
- Organic and inorganic compounds as another form of classification (distinction between the two);
- Symbols of simple elements (the first 20 elements of the periodic table as well as several common elements).

3. Molecules and Atoms

- Kinetic molecular theory; concept of kinetic energy and heat (brief description);
- Parts of the atom (protons, neutrons and electrons);
- Arrangement of electrons, protons and neutrons of the first 20 elements in the periodic table. Electron configuration according to the Bohr model, with reference to the periodic table (families and periods);
- Concept of "isotopes" and current applications;
- Concept of atoms combining to form compounds;
- Molecular models. Simple molecular formulas and nomenclature (compounds may be formed using the rule of eight);
- Physical and/or chemical changes (experimental approach and everyday occurrences);
- Relationship between energy and chemical reactions; the different forms of energy and their interrelationship. Distinction between exothermic and endothermic;
- Simple chemical equations: concept, symbols and balancing of simple equations;
- Concept of the conservation of mass;
- Acids and bases (general ideas and examples of everyday reactions).

4. Work and Energy

- Concepts of force: effects of a force; measurement of a force;
- The concept of inertia, action and reaction. Examples of jet propulsion. Centripetal, centrifugal force and friction. Gravitational force (link between mass and weight). Examples of these principles in everyday life;

- Mechanical advantage, the theory and practice of simple machines: levers, pulleys, inclined planes, etc.;
- Concept of work: general equations and simple calculations;
- Concept of power and simple calculations.

5. Thermal Energy

- Sources of heat; units of heat;
- Specific heat;
- Difference between heat and temperature; units and measurements;
- Thermal exchanges; conductors and insulators; refrigeration, heating; etc.

6. Heat Engines

- Principle of expansion;
- Operation of certain heat engines: steam engines, turbines, internal combustion engines, external combustion engines, 4-cycle motors, etc.

7. Light

- Sources of light;
- Propagation of light;
- Reflection, refraction; lenses.

8. Magnetism

- Types of magnets;
- Attraction laws;
- Magnetic field concept;
- Compass;
- Machines functioning by means of a magnetic field produced by a magnet and/or an electric current.

9. Electricity

- Electrostatics;
- Electric current;
- Electrical circuits: series and parallel;
- Ohm's law;
- Measurement of energy. Utilization costs of electrical equipment.

NOTE: Students' abilities and allotted time will determine how far teachers can go in teaching the suggested concepts. Teachers should always keep in mind the concrete and practical, rather than the abstract and theoretical aspects of this program.

PHYSICS BLOCKS I AND II, PHYSICS 441

These three programs have been developed within the context of a 100-hour time allotment; consequently, there was no need to provide modification for them in this document. Teachers who are already teaching these programs can continue to do so. However, it is not recommended that teachers introduce them now as new ones will soon be released.

PHYSICS 522 AND GENERAL PHYSICAL SCIENCE 422

Useful information will be provided in the near future to help teachers implement Physics 522. Regarding General Physical Science 422, it was not deemed necessary to provide directions for teaching this program in 100 hours as it is not widely implemented at present. However, if teachers wish to teach the program in 100 hours and have not already made the necessary changes, they can obtain the appropriate information by contacting the:

Coordinator of Science Programs
Ministère de l'Éducation
Edifice "G", 9^{ème} étage
Direction de la formation générale
1035 de la Chevrotière
Québec (Québec)
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8687-755
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